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INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA.

Vol. II.

Part 3. SIWALIK AND NARBADA EQUIDÆ.

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WITH 5 PLATES, Nos. XI to XV.

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NOTICE.

SIWALIK FOSSILS FOR EXCHANGE.

Specimens of the teeth or bones of the following genera of Siwalik vertebrata are available at the Indian Museum in exchange for named teeth or bones from the pliocene, miocene, or eocene of Europe or America. Specimens of *Dinotherium*, *Mastodon longirostris*, or *Hippotherium gracile* are not required. Apply to R. Lydekker, care of Superintendent, Geological Survey of India, Indian Museum, Calcutta.

Dinotherium.
Mastodon (2 or 3 sp.)
Stegodon (2 sp.)
Loxodon.
Sus (2 sp.)
Hippohyus.
Hippopotamus.
Rhinoceros.
Acerotherium.
Hippotherium (2 sp.)
Equus.
Antilope.
Portax.
Crocodilus.
Gharialis.
Batagur.
Trionyx.
Emyda

the complete isolation of the anterior 'pillar': in the much-worn tooth, however, this 'pillar' is united to the first inner 'crescents' in *Hippotherium*, as in *Equus*.[1] The plications of the central folds of enamel in the upper molars are generally greater in the former than in the latter genus.

Genus I. HIPPOTHERIUM, Kaup.

HIPPARION, Christol.

This genus may be shortly defined as follows. Tridactyle[2] horses, in which the first pillar, in the upper molars, is disconnected from the first inner 'crescent' for at least three-quarters of its length.

Species 1. HIPPOTHERIUM ANTILOPINUM, Falc. and Caut.

SYNS: HIPPARION ANTILOPINUM, Gaudry. EQUUS PRIMIGENIUS, von Meyer.

History.—As stated in the introduction, this species seems to have been first named in the "Fauna Antiqua Sivalensis," and we must, therefore, trust to the figures there given, and the measurements in the descriptions of the plates, for its identification. In plate LXXXII of that work there are drawn several specimens of the dentition, which must be taken as the types of the species. These will be referred to as we proceed.

At a later period, as already noticed in the introduction, H. von Meyer referred all the remains of Indian hippotheres then known, to the European *Hippotherium gracile* (*Equus primigenius*). We shall subsequently see that there is good evidence to show that there are, at least, two Indian species of the genus, but that von Meyer's conclusion as to the identity of *H. antilopinum* with *H. gracile* may possibly be correct.

M. Gaudry's conclusion as to the probable monodactyle character of this species will be alluded to below and shown to be untenable.

Upper molar series.—In figure 13 of plate LXXXII of the "Fauna Antiqua Sivalensis," an upper jaw, with the molar series, of *Hippotherium antilopinum* is figured, and described as belonging to the left side. A cast of this specimen, however, in the Indian Museum, shows that the figure has been reversed, and that the jaw really belongs to the right side. It contains six teeth, which seem to be the three true molars, and the three last premolars. The portion of the bone where the persistent milk-molar should be has been broken away, so that that tooth

[1] *Vide* Gaudry, *op. cit.*, fig. 166.

[2] This is on the supposition that M. Gaudry's conclusions as to the monodactyle character of *H. antilopinum* are incorrect.

may have been present in the complete jaw. The last true molar has only just come into wear. This specimen will be termed *a*.

In figure 16 of the same plate a palatal specimen is figured; it shows the three true molars and the last premolar; it is of slightly larger size than the last specimen and will be alluded to as specimen *b*.

In figure 18 of the same plate a detached upper molar is figured of the natural size.

In figure 1 of plate XI of this memoir there is drawn part of the left upper molar dentition of a species of *Hippotherium*, collected by Mr. Theobald in the Siwaliks of Niki, in the Punjab. The second tooth in this specimen (pm. 4) being less worn than the succeeding tooth, is inferred to be the last premolar, whence the four teeth will be, respectively, the 3rd and 4th premolars (pm. 3, pm. 4) and the 1st and 2nd true molars (m. 1, m. 2). From the size of the teeth in this specimen (which we shall call specimen *c*) it is inferred to belong to *H. antilopinum*. The teeth are of the normal hippotherian type, showing the characteristic isolated anterior 'pillar,' and the plications of the central islands of enamel. The premolars are somewhat larger than the true molars, and the grinding surfaces of all the teeth are approximately square.

In the following table the dimensions of the three specimens above noticed are compared together; the specimens are indicated by the letters given above—

	a.	c.	b.
Width of palate posteriorly	...	..	2·0
„ „ „ between 3rd premolars	...	...	1·9
Length „ molar series	5·3	...	...
„ „ three true molars	2·36	...	2·5
„ „ 1st premolar	1·25	...	—
Width „ „ „	0·83	...	...
Length „ 2nd „	0·96	0·96	..
Width „ „ „	0·95	0·95	...
Length „ 3rd „	0·93	0·9	0·9
Width „ „ „	0·86	0·91	0·9
Length „ 1st true molar	0·8	0·81	0·8
Width „ „ „	0·85	0·88	0·9
Length „ 2nd „	0·85	0·82	0·8
Width „ „ „	0·76	0·78	0·85
Length „ 3rd „	0·8	...	0·85
Width „ „ „	0·55	...	0·75

The comparatively slight variations in these dimensions leave little room for doubt that the three specimens belong to the same species, seeing that no difference in the form of the teeth can be detected.

Upper milk-molars.—The next specimen for notice is the anterior portion of the palate of a colt, also collected by Mr. Theobald in the Siwaliks of the Punjab near the village of Niki. In figure 2 of plate XI of this volume the dentition of the left side of this specimen is figured. The teeth shown are the four milk-molars (mm. 1 to mm 4.), and the germ of the first true molar (m. 1), which has never come into

use. The isolation of the anterior 'pillars' in these teeth shows that they belong to a *Hippotherium*, while the existence of a larger form of milk-molars of the genus in the Siwaliks (to be noticed in the sequel) renders it probable that these teeth belong to the present smaller species.

The first milk-molar (mm. 1) is a small sub-cylindrically shaped tooth: the second milk-molar (mm. 2) is elongated; the third and fourth teeth of this series (mm. 3: mm. 4) approach a square in cross-section.

As it is mainly from the characters of the upper milk-molars that the distinctness of the next species is inferred, it will be necessary to examine the characters of these teeth somewhat more closely. In all the three larger teeth the anterior 'pillar' is subcylindrical, and is placed far in between the two inner 'crescents,' so that by the presence of a large amount of cement the inner wall of the crown presents a smooth face, without any projection of the hinder border of the anterior 'pillar.' In the second milk-molar there is an infolding of enamel on the inner side of the produced anterior extremity of the crown: the posterior 'pillar' presents the peculiar character of being separated from the posterior inner 'crescent.' In the second and third milk-molars the posterior 'pillar' does not extend backwards as far as the hinder border of the crown. In all these teeth the plications of the enamel in the central islands are of great complexity. The teeth are coated very thickly with cement, which nearly obliterates the ridges on their outer walls.

The dimensions of the specimen are as follows:—

Width of palate between 1st milk-molars	1·82
„ „ „ last „	2·0
Length „ four milk-molars	3·72
„ „ three last „	3·52
„ „ 1st milk-molar	0·48
Width „ „ „	0·32
Length „ 2nd „	1·12
Width „ „ „	0·89
Length „ 3rd „	1·01
Width „ „ „	0·94
Length „ 4th „	1·1
Width „ „ „	0·94

Mandible.—In figures 14 and 14a of plate LXXXII of the "Fauna Antiqua Sivalensis" two views are given of a fragmentary mandible of a small equine animal referred to the present species. In the description of the plate the specimen is said to contain the three premolars and the first true molar: an inspection of the figure, however, shows clearly that the fourth tooth (the first true molar) is less worn than the preceding tooth; hence the three anterior teeth must be milk-molars, and not premolars. I am unable to say whether the specimen belongs to this or the next species.

In figure 3 of plate XII of this volume there is drawn a fragment of the left ramus of the mandible of an equine animal collected by Mr. Theobald in the

Siwaliks of the Punjab. As the specimen comes from a horizon in the Siwaliks (as inferred from its mineral condition), where no remains of *Equus* occur, and as it presents certain peculiarities characteristic of the lower dentition of *Hippotherium*, it may be referred to that genus. Since the specimen is smaller than, and of different proportions from, another jaw of the same genus referable to the next species, it seems probable that it may be referred to *H. antilopinum*. This specimen shows five teeth, the two anterior of which (pm. 3, pm. 4) are stouter and less worn than the succeeding tooth (m. 1,) whence it is inferred that the five teeth are respectively the two last premolars, and the three true molars.

The premolars (pm. 3, pm. 4) are considerably wider and stouter than the true molars; the last true molar is extremely thin: the four anterior teeth exhibit at their antero-external angles a semi-detached column of enamel, very characteristic of the lower molars of this genus.[1] The fragment of the mandible remaining shows that the inferior border was highly convex towards the middle.

The dimensions of the specimen are as follows:—

Depth of jaw at pm. 3	2·1
„ „ „ m. 1	2·65
Length „ five teeth	5·0
„ „ three true molars	2·92
„ „ 3rd premolar	1·08
Width „ „ „	0·61
Length „ 4th „	1·1
Width „ „ „	0·6
Length „ 1st true molar	0·94
Width „ „ „	0·5
Length „ 2nd „	0·86
Width „ „ „	0·48
Length „ 3rd „	1·02
Width „ „ „	0·43

Lower milk-molars.—In figure 1 of plate XII there is represented a part of the left mandible of a young hippothere, collected by Mr. Theobald in the Punjab. This specimen shows four teeth, namely, the three last milk-molars (mm 2, mm 3, mm. 4), (inferred to be such from the fourth tooth (m. 1) in the specimen being less worn than the preceding one), the first true molar (m. 1) just touched by wear, and the alveolus of the second true molar. The specimen is inferred to belong to a *Hippotherium* from the district whence it was obtained, and from the presence of the detached column of enamel on the outer side of the third milk-molar. From the exact similarity of the first true molar (m. 1) in this specimen with the corresponding tooth in the last specimen, the jaw is inferred to belong probably to *H. antilopinum*. It will be noticed that the milk-molars are of smaller dimensions than the premolars in the last specimen. The length of the three milk-molars is 3·7 inches.

[1] This column is scarcely perceptible in the figure; it is well shown in figure 10 of plate V of Gaudry's "Animaux Fossiles du Mont Léberon."

Limb-bones.—In plates LXXXIV and LXXXV of the "Fauna Antiqua Sivalensis" a large series of limb-bones of Siwalik equine animals has been lithographed, and in many cases specifically assigned either to *Equus sivalensis* or *Hippotherium antilopinum*. We are not, however, informed on what grounds these determinations were made, but it appears that in general the larger specimens have been assigned to the former species, and the smaller to the latter. If, however, we examine into the matter more closely, we shall find that this does not hold as an invariable rule. Taking the case of the metatarsus, we find that in figure 4 of plate LXXXIV a specimen of this bone referred to *Equus sivalensis* has a length of 11·1 inches; while a specimen (plate LXXXV, figure 12) referred to *Hippotherium antilopinum* has a length of 10·4 inches. Another specimen, however (plate LXXXIV, figure 21), assigned to the former genus, has a length of only 10·5 inches, and is much slenderer than the first specimen. In the Indian Museum there is a specimen of an equine metatarsus from the topmost Siwaliks, in which hitherto no remains of *Hippotherium* have been found: this bone is somewhat smaller than the one assigned by Falconer and Cautley to *H. antilopinum*, and yet belongs to an *Equus*. It will be shown below that the proximal phalangeal bones referred by Falconer and Cautley to *H. antilopinum* really belong to *Equus sivalensis*.

From the foregoing considerations it seems to me that Falconer's identification of the limb-bones of this species is certainly erroneous, and, therefore, that M. Gaudry's conclusions as to the probable monodactyle character of *H. antilopinum*, based on the absence of the facettes for the lateral metacarpals or tarsals, on the 'cannon-bones' assigned to this species by Dr. Falconer, must likewise fall to the ground. It may be observed, however, that if, as was almost certainly the case, the hippotheres have been gradually modified into the true horses, they must at some time or other have lost their accessory digits, and the anterior 'pillar' of the upper molars must have been become connected with the main body of the tooth. It is quite possible, therefore, if not probable, that these changes did not take place synchronously, and, accordingly, there would be nothing improbable in meeting with an animal having, as M. Gaudry considers to have been the case with the present species, the digitation of the horse, coupled with the dentition of the hippothere.

There are but few limb-bones in the Indian Museum, which can with any certainty be referred to this species. Among these may be mentioned the proximal phalangeals, which are of the same shape as the corresponding bone of the next species (plate XIII), but about two-thirds the size. They are quite different from the bone assigned by Falconer to this species in the "Fauna Antiqua Sivalensis," plate LXXXIV, figure 11.

Comparison with H. gracile.—As far as can be judged, it appears probable that Dr. Falconer distinguished his Indian hippothere from the European species on the ground of its smaller size. M. Gaudry, however, in his great works on the Pikermi and Mount Léberon fossils, has shown that the latter species is subject

to such variation in size,[1] that it would seem that this ground of distinction will not hold; and we are, therefore, driven to depend on the characters of the teeth themselves. This renders the task of indicating precise specific characters one of great difficulty, as there are such extremely insignificant differences between the teeth of all the species of the genus.

Between the four middle upper molars of *H. antilopinum* figured here, and the corresponding teeth of *H. gracile*, I cannot find any crucial point of distinction, and they might, as far as I can judge, be referred to the same species. Almost the only difference seems to be that in the Indian form the anterior 'pillar' is more completely enclosed in the cement, and is hence less conspicuous on the inner surface.

In the upper milk-molars a few points of difference can be detected between the European and Asiatic forms. In the former[2] the plications of the central enamel islands are less complex than in the latter; while the anterior 'pillars' are less completely embraced in the crowns of the teeth in the former. In the second milk-molar of *H. gracile* both the 'pillars' are connected with the 'crescents' by isthmuses of dentine, while in the corresponding tooth of *H. antilopinum* both are completely isolated. Further, in the same tooth of the latter there is a distinct infold of enamel from the inner side of the produced anterior angle, which is entirely wanting in the corresponding tooth of the former.

The mandible of the Indian form is decidedly more curved inferiorly than that of the European form.

It will be seen, therefore, that the points distinguishing *H. antilopinum* from *H. gracile* are extremely slight, and it is not improbable that von Meyer's identification of the two may be correct. It appears to me best, however, seeing that there are some minute points of difference, to retain, at all events for the present, the two specific names, though it may be doubted whether the two forms should be ranked as races or species.

American hippotheres.—All the American species of the genus seem to be distinguished by the simpler structure of the enamel folds. Should any of them, which is extremely unlikely, turn out to be the same as the Indian species, the name of the latter has the priority of all.

Distribution.—Remains of this species have been obtained throughout the sub-Himalayan Siwaliks, but not from Sind or Burma. An atlas of a small species of horse in the Indian Museum from Perim Island has been referred by Dr. Falconer, with considerable probability of correctness, to the present species. It is uncertain whether the hippotherian teeth from China in the British Museum, mentioned by M. Gaudry in the passage already quoted, should be referred to this or the next species.[3]

[1] Compare fig. 7, pl. XXXIV of "Animaux Fossiles et Géologie de l'Attique," with fig. 9 of pl. V, of "Animaux Fossiles du Mont Léberon."

[2] See "Animaux Fossiles du Mont Léberon," pl. V, fig. 7.

[3] These teeth are referred to in the "Quarterly Journal of the Geological Society of London." Vol. IX. p. 354.

Species 2. HIPPOTHERIUM THEOBALDI, *nobis*.

Synonyms—EQUUS PRIMIGENIUS, Meyer, SIVALHIPPUS THEOBALDI, *nobis*.

History.—As stated in the introduction, certain remains of this species were originally described,[1] as belonging to a new genus, under the name of *Sivalhippus theobaldi*. It was, however, subsequently discovered[2] that the teeth on which this new genus had been founded, in place of being premolars, as was originally considered to be the case, were really milk-molars, and were then seen to belong to *Hippotherium*. It was added in the same notice that certain teeth described by H. von Meyer[3] from India, as belonging to *H. gracile*, should be referred to the new species under the name of *H. theobaldi*. It may be added that this determination was made under the erroneous impression that von Meyer had intended to distinguish the teeth in question from *H. antilopinum*, whereas he had intended to unite that species with *H. gracile*. The distinctness of this species rests solely on the characters of the upper milk-molars, the true molars, which are referred to it, presenting no characters, except their larger size, by which they can be sufficiently distinguished from those of *H. antilopinum*, and, as far as I can judge, closely resembling the corresponding teeth of the larger variety of *H. gracile*.

Upper milk-molars.—The teeth of the specimen on which the species was originally founded are represented in figure 4 of plate XI. The specimen was obtained by Mr. Theobald from the Siwaliks of the village of Kaipar, in the Punjab. It consists of a fragmentary portion of the left maxilla, containing three complete teeth (mm. 2, mm. 3, mm. 4) and the broken base of a smaller anterior tooth (mm. 1). To the rear of the last tooth (mm. 4) there is seen the alveolus of a fifth tooth, which had not come into use at the death of the animal: this shows that the existing teeth belong to the milk-molar series. From the isolation of the anterior 'pillars' of the molars the specimen must be referred to *Hippotherium*, while from the great difference in the form of these teeth from the upper milk-molars of *H. antilopinum*, drawn in figure 2 of the same plate, it is inferred that they must be assigned to a second Indian species of the genus, which it has been proposed to call *H. theobaldi*.

The teeth belonged to a very young colt, as they are but slightly touched by wear. In spite, however, of the very small degree of attrition of these teeth, the first true molar had cut the gum, as is shown by the condition of its alveolus. This unusually early appearance of this tooth seems to distinguish this jaw from the jaws of all other horses.

The first tooth was small and sub-cylindrical. The remaining teeth are oblong in shape (the second milk-molar being produced into the usual angle), and, thereby, seem to be distinguished from those of other species of the genus, which are more

[1] 'R. G. S. I.,' Vol. X, p. 31. [2] *Ibid*, p. 82. [3] "Palæontographica," Vol. XV, p. 17.

nearly square in shape;[1] and in which respect they resemble the milk-molars of the genus *Equus*.

The points distinguishing these teeth from the corresponding teeth of *Hippotherium antilopinum* will be best exhibited by a comparison of the two series. In the following table the dimensions of the specimen under consideration are given in the first column, and those of the corresponding teeth of *H. antilopinum* in the second.

Length of three last milk-molars	4·0	3·52
„ „ first milk-molar	0·32	0·48
Width „ „ „ „	...	0·32
Length „ second „ „	1·55	1·42
Width „ „ „ „	0·98	0·89
Length „ third „ „	1·28	1·01
Width „ „ „ „	0·96	0·94
Length „ fourth „ „	1·30	1·1
Width „ „ „ „	0·97	0·94

These dimensions show the much greater proportionate length of the milk-molars of the former species. The other differences are the following.

In *H. antilopinum*, the anterior 'pillar' is sub-cylindrical, and completely enclosed by cement in the mass of the crown: the posterior 'pillar' does not extend backwards as far as the hinder border of the crown; while in the second milk-molar the same 'pillar' is disconnected from the body of the tooth. The enamel is much plicated, and the cement of great thickness.

In *H. theobaldi*, on the other hand, the anterior 'pillar' is much compressed, so as to be longitudinally elongated; it also stands out distinctly from the crown, so that its posterior border forms a free sharp edge: the posterior 'pillar' extends backwards as far as the hinder border of the crown; while in the second milk-molar the same 'pillar' is united with the adjacent 'crescent.' The enamel is but slightly plicated, and the cement thin.

These points of distinction appear to me so marked as to preclude all idea of referring the two specimens to the same species. It may be noticed that in nearly all the points in which the milk-molars of *H. theobaldi* differ from those of *H. antilopinum* (and also from those of *H. gracile*) they approach the characters of the corresponding teeth of *Equus*. It will be observed that 'sprigs' of enamel jut forth from the space between the two 'crescents' very close to the anterior 'pillar,' foreshadowing the connection which exists in *Equus*.

The milk-molars of *H. gracile*, as has been noted above, are so like those of *H. antilopinum*, that we have found very few points of distinction: hence the milk-molars of *H. theobaldi* will differ from those of *H. gracile* in much the same points as they do from those of *H. antilopinum*. According to M. Gaudry's figure of the milk-molars of *H. gracile*, these teeth seem to be slightly more elongated than those of *H. antilopinum*, and are therefore intermediate between the latter and those of

[1] *Vide* plate XI, fig. 2, and plate V fig. 7, of "Animaux Fossiles du Mont Léberon."

H. theobaldi. The second milk-molar of the latter species agrees with the corresponding tooth of *H. gracile* in the union of the posterior 'pillar' with the adjacent 'crescent,' and differs by the presence of the infold of enamel at the inner side of the anterior angle.

Second specimen.—In a second specimen of the milk-molars of *H. theobaldi* (Indian Museum, No. C. 154) from Niki, containing the two last teeth of that series, the essential characters are the same as in the type specimen: the dimensions are as follows:—

Length of third milk-molar	1·12
Width „ „ „	0·87
Length „ fourth „	1·2
Width „ „ „	0·88

The disproportion between the two diameters is here greater than in the first specimen.

Maxilla of first specimen.—The fragment of the maxilla in which the figured teeth are contained is too imperfect to give any idea of the characters of the cranium, except the fact that it was furnished with a very large lachrymal depression or 'larmier.'

Distinctness as a species.—I am unable to find in any of those of the American species of *Hippotherium* of which the milk-molars have been described any close resemblance to the teeth described above, and therefore come to the conclusion that they are rightly referred to a distinct species.

Upper true molars.—Seeing that the upper milk-molars have afforded evidence of two species of Indian hippotheres, it now remains to discover whether we can distinguish between the true molars of these species. In figure 3 of plate XI, there are represented four teeth of the left upper permanent molar series of a hippothere from Mr. Theobald's Niki collection, of somewhat larger dimensions than those of *H. antilopinum*, and also differing slightly in form from those teeth. Since the upper milk-molars of *H. theobaldi* are somewhat larger than those of *H. antilopinum*, it is inferred that the same rule holds good with regard to the true molars, wherefore the teeth in question have been assigned to the former species. It may be added that if the milk-molars had not been known, it would have been doubtful whether the true molars would have afforded ground for the formation of two species.

The figured specimen consists of a fragment of the left maxilla containing four complete teeth, and the alveolus of another tooth on either side of the four remaining ones. The second remaining tooth, counting from the left (p. m. 4), is less worn than either of the teeth on its two sides, and must accordingly be the last premolar: the four teeth will, therefore, be respectivly the third and fourth premolars (p. m. 3, p. m. 4), and the first and second true molars. The crowns of the teeth are nearly square in cross-section, and the premolars are considerably larger than the true molars. The anterior 'pillars' are compressed longitudinally, and stand out distinctly from the crown: small processes of enamel project from the space

between the inner 'crescents' towards these 'pillars.' The posterior 'pillars' are constricted at the point of union with the posterior 'crescents;' this constriction, however, is only characteristic of an early stage of detrition and disappears at a later period, as is shown in the single worn tooth represented in plate XIII, figure 1. The enamel is much plicated.

In figures 1 and 2 of plate XIII are represented two detached upper molar teeth of the same species, the first of which (fig. 2) is the second right premolar, and the other, the third or fourth of the left side of the same series. The former tooth is figured to show the characters of the first premolar, and the second to show a good example of a well-worn crown of one of the middle teeth. The only point that claims any particular notice is that there is a plication of the enamel on the inner side of the produced anterior angle of the second premolar, which seems to be constant in all specimens of this tooth.

The dimensions of the three last premolars, and the second and third true molars, are as follows:—

Length of four teeth of specimen drawn in plate XI, fig. 3	4·4
Length „ second premolar	1·6
Width „ „ „	1·1
Length „ third „	1·24
Width „ „ „	1·12
Length „ fourth „	1·13
Width „ „ „	1·15
Length „ first true molar	1·0
Width „ „ „ „	1·05
Length „ second „ „	1·03
Width „ „ „ „	1·03

Distinctions and differences.—As I have before observed, it seems doubtful whether the evidence of the permanent molars alone would have been sufficient for the separation of the present species from the last; seeing, however, that the milk-molars afford undoubted evidence of the distinctness of the two, we may note what points of difference can be found between the permanent molars. It will first of all be seen from the measurements given above that the permanent molars of *H. theobaldi* are of considerably larger size than those of *H. antilopinum;* in the former species, moreover, the excess of size of the premolars over the true molars is considerably greater than in the latter. The anterior 'pillars' in the molars of the former are more compressed laterally, and stand out more distinctly from the body of the teeth than in the latter. These appear to be the main points of difference between the permanent molars of the two species.

The permanent molars of *H. gracile* seem to be in general somewhat smaller than those of *H. theobaldi*; while their anterior 'pillars' are more cylindrical. The projections of enamel from the space between the two inner 'crescents' do not approach so near to the anterior 'pillars' in the former as in the latter. In the second premolar of the European species the folds of the enamel occurring on the inner side of the anterior angle of this tooth in the Indian species are wanting.

I cannot identify the molars of the present species with any of the American species of the genus, which are mostly characterised by their smaller size, and by the lesser degree of plication of the central enamel islands.

Mandible.—In figure 2 of plate XII there is figured a portion of the left ramus of the mandible of a *Hippotherium*, obtained by Mr. Theobald in association with the maxilla last described, and which doubtless belonged to the same individual. The specimen was, in all probability, originally complete, but has been broken, and lost some pieces during the process of extraction from its bed. The parts now remaining comprise the greater part of the left ramus, from the base of the coronoid process to the commencement of the symphysis, but wanting a small part of the middle, and the last premolar. The other fragment consists of the hinder half of the right ramus as far as the front of the last premolar. The figured fragment shows the second and third premolars (pm. 2, pm. 3), and the three true molars (m. 1 to m. 3), while the right ramus contains the last premolar and the true molars.

The jaw belonged to an animal which had just attained to full maturity, as the last true molar has been but a short time in use. The first premolar, or milk-molar, has disappeared. The teeth are of large size and great thickness, and the premolars are much larger than the true molars.[1] The cement is of unusual thickness, forming distinct ledges on the sides of the crown. The free edges of the enamel are slightly crenulated. The inferior border of the ramus is nearly straight below the molars, and the inflection for the symphysis commences one inch in advance of the second premolar. The dimensions of the specimen (combining those of the two rami) are as follows:—

Length of six molars	6·8
Depth „ jaw at second premolar	2·08
„ „ „ „ last true molar	4·1
Length „ second premolar	1·3
Width „ „ „	0·72
Length „ third „	1·13
Width „ „ „	0·8
Length „ fourth „	1·12
Width „ „ „	0·75
Length „ first true molar	1·0
Width „ „ „ „	0·68
Length „ second „ „	1·07
Width „ „ „ „	0·62
Length „ third „ „	1·3
Width „ „ „ „	0·61

Distinctions and differences.—The above dimensions indicate an animal of somewhat larger size than the Tibetan kiang (*Equus hemionus*). The teeth are larger and stouter than those we have assigned to *H. antilopinum*, the increase of thickness being due in great part to the large quantity of cement. The inferior border of the jaw seems to be straighter than in that of *H. antilopinum*. Much

[1] In the figure the space left for the last premolar is not of sufficient length.

the same differences occur between the present teeth and the lower molars of *H. gracile*. The jaw of *H. theobaldi* is further distinguished from that of *H. gracile* by the smaller interval separating the first of the molar series from the commencement of the symphysis.

In figure 4 of plate XII there are represented the teeth of a broken right ramus of the mandible of an equine animal collected by Mr. Theobald at Jabi, in the Punjab. The specimen shows the last premolar (pm. 4) and the three true molars (m. 1, m. 2, m. 3). As no remains of the genus *Equus* have been obtained from the district where this specimen was collected, it is inferred to belong to *Hippotherium*. In the dimensions of the jaw and length of the teeth, the specimen agrees with the above described jaw of *H. theobaldi*. The teeth differ, however, from those of the latter specimen by the enormous quantity of cement with which they are coated, especially noticeable in the premolar. The 'crescents' seem also to be less regular in form than in that specimen. A third mandible in the Indian Museum (No. C. 161) exhibits less cement than the specimen drawn in figure 2 of plate XII, and it, therefore, seems that the quantity of cement cannot be taken as a character of specific value, and all three specimens are consequently referred provisionally to one and the same species.

Limb-bones.—From the fertile fossil locality of Niki, in the Punjab, so frequently alluded to in previous pages, Mr. Theobald has obtained several portions of limb-bones of a large hippothere, probably belonging to the same individual as the upper and lower jaws. These remains comprise the upper portion of a tibia, the distal ends of a pair of radii, and a hind and fore-foot in a more or less complete state. I have nothing to note on the first three of these specimens, but have a few remarks to make regarding the feet, one of which is figured in plate XIII, figure 3, of this volume. This specimen belongs to the fore-limb, as is determined by its difference from another foot with a complete metatarsal. The distal extremity of the metacarpus is all that remains of that bone: the first and second medial phalanges are complete, but the terminal phalange has been broken. On the right side are seen the three phalanges of one of the lateral digits, and on the opposite side the distal extremity of the lateral metacarpal. The central metacarpal bears flat facettes on its posterior aspect for articulation with the lateral bones. From the slenderness of the remaining lateral metacarpal it would seem that, as in *H. gracile*, these bones did not extend continuously along the whole length of the median metacarpal. The bones of this foot seem to be nearest in size to those of the stout variety of the Pikermi hippothere described by M. Gaudry.[1]

In the specimen of the hind-foot in the Indian Museum, the lateral digits are smaller than in the figured specimen of the fore-foot.

Distinctness as a species and distribution.—The specimens examined above leave but little doubt as to the former existence of a second species of Siwalik hippothere, mainly distinguished from *H. antilopinum* by the difference in the

[1] "Animaux Fossiles et Géologie de l'Attique," pl. xxxv, fig. 13.

structure of its upper milk-molars, and by its generally larger size. The remains of this species are at present only known to me from the Siwaliks of the Punjab, and from Perim Island: from the latter locality certain upper molars, now in the Indian Museum, were catalogued by Dr. Falconer as belonging to *Equus*.[1] It is not impossible that the extremity of the mandible of an equine animal from Burma represented in figure 12 of plate LXXXII of the "Fauna Antiqua Sivalensis" may belong to the present species, as the Irawadi beds generally yield fossils of an old type. It is also possible that the fossil hippotherian teeth from China, referred to above, may belong to this species.

Genus II: EQUUS, Linné.

Horses in which the feet are normally monodactyle and the anterior 'pillar' of the upper molars united throughout its length with the adjacent 'crescent.'

By many modern zoölogists the old genus *Equus* is subdivided into *Equus*, containing the horse only, and *Asinus*, containing all the other living members of the family; as, however, the distinctions between these two groups rest solely on external characters, they are manifestly inapplicable to any but the living species.

Species 1. Equus sivalensis, Falc. and Caut.

Previous history.—With the exception of the notice of fossil Indian horses by the late Sir W. E. Baker already referred to, we have only the plates in the "Fauna Antiqua Sivalensis" to depend upon for the identification of this species. The specific name seems to have first appeared in that work. As it appears to me that the remains of two species have been figured in the "Fauna Antiqua Sivalensis" under the name of *E. sivalensis*, it is necessary to determine which specimens are to be considered as the type of that species. I have accordingly taken the skull represented in figures 1, 1*a*, 1*b* of plate LXXXI of that work as the type, since it is the most perfect specimen figured.

Upper molar series.—An inspection of the figures of the teeth in the above-mentioned type skull, or still better, of those of a cast of the same specimen, shows that the specimen bears the two last premolars and the three true molars. The teeth are very much worn, the first enamel island having totally disappeared in the penultimate premolar, and both these islands in the first true molar. The grinding surfaces of the molar series are characterised by the small size of the anterior 'pillar' in the premolars, the grinding surface of which is never larger than the same surface in the second true molar.

Another specimen of a much worn upper molar series, drawn in figure 3 of plate LXXXII of the same work, exhibits the same general dental characters.

In figure 2 of plate XIV of this volume is represented the complete left upper permanent molar dentition of the skull of a horse, collected by Mr. Theobald in the

[1] See "Pal. Mem.," Vol. I, page 188.

Siwaliks near the village of Pádri in the Punjab. The teeth of this specimen are in an intermediate condition of wear, and the first premolar (pm. 1) is seen to be persistent. These teeth agree with the specimens last noticed in the comparative shortness of the grinding surface of the anterior 'pillars' of the premolars, *i.e.*, they are not longer than the corresponding surface in the second true molar (m. 2); the specimen is accordingly referred to the present species.

In figure 1 of the same plate there are represented the five last teeth of the right upper molar series of a horse obtained by Mr. Theobald from the higher Siwaliks of the village of Rúpúr in the Punjab. These teeth are somewhat less worn than those of the previous specimen, and exhibit the characteristic shortness of the grinding surface of the anterior 'pillars' of the premolars, this being especially noticeable in this specimen, where this surface in the last premolar (pm. 4) is shorter than in the first true molar (m. 1).

The last specimen of the upper molar dentition of this species to be noticed is contained in a fragment of the right maxilla: another of Mr. Theobald's numerous Siwalik specimens (No. C 180, Ind. Mus.). In this specimen, which has not been figured, the four last teeth of the molar series are exhibited, the last true molar having only just come into wear: this specimen, therefore, belongs to a younger individual than either of the others. In it the length of the grinding surface of the anterior 'pillar' of the last premolar is considerably shorter than the corresponding surface of the first true molar, the respective lengths being 0·4 and 0·51 inch.

Taking, therefore, the five specimens above mentioned, which exhibit the teeth at all stages of wear, we find it to be a constant character of the upper molars of *Equus sivalensis* that the grinding surfaces of the anterior 'pillars' of the premolars are not longer than those of the later true molars, and are frequently shorter than the corresponding surface of the first true molar. The number of specimens examined, and their different ages, leave little doubt as to the trustworthiness of this character. It may be noticed that a considerable difference occurs in the size of the molars of the two specimens figured in this volume, but it does not appear to me that this can be considered as more than an individual or sexual character. In the only specimen exhibiting the complete molar series, the first premolar (milk-molar) is persistent, and of considerably larger size than the same tooth in living horses.

Comparison.—The difficulty of arriving at any satisfactory conclusion merely from a comparisons of the teeth of the horse-family is well instanced by the numerous so-called species which have been made from the European fossil remains of the domestic horse (*Equus caballus*). The teeth of many of the different living species are, indeed, so much alike that it would, I think, be impossible to distinguish many of them by the characters of the molar teeth alone. In the case of the fossil Siwalik horse, from the materials at my command, my comparisons must, perforce, be limited to the living Asiatic species.

In *Equus caballus* I cannot discover any instances where the anterior 'pillar' is as small as it frequently is in *Equus sivalensis*. In the former the second pre-

molar seems always to be worn very unequally, being more abraded in front than behind; in the latter the wear of this tooth is equable. In the former, again, the first milk-molar is of much smaller size than in the latter, and comparatively seldom persists. The larger form of *E. sivalensis* indicates an animal of, at least, fifteen 'hands' in height.

In *E. onager*, of north-western India and Persia, the anterior 'pillar' in all the molars is of large size, and is larger in the last premolar than in any of the true molars. The first milk-molar, if developed, seems to be always shed at a very early period.

In *Equus hemionus*, or the kiang, of Tibet, the upper molars in the matter of form are extremely close to those of *E. sivalensis*, and it seems to me that it is doubtful whether we could distinguish the molar series of the two forms if both were found in the fossil state. The molars of the living species do not, however, ever attain to the dimensions of the larger individuals of the fossil species. In the kiang, moreover, the first milk-molar is alway very minute, and in all the skulls that have come under my observation is shed before any of the premolars appear. These, however, are but slight differences, and I cannot but think that there is a very intimate relationship between these two species, an inference which is supported by the characters of the cranià of the two forms.

Cranium.—The specimens of the cranium which can with certainty be referred to this species are two, *viz.*, the one already referred to in the "Fauna Antiqua Sivalensis," and the one in the Indian Museum to which the molar dentition in figure 2 of plate XIV belongs. Both these specimens have lost their premaxillæ. A third skull of a Siwalik horse, in the Indian Museum, exhibits these bones, but, as all the molar teeth, except the two last, are wanting, I am not quite sure of the species to which that specimen belongs, though from the form of the skull I am inclined to refer it to *E. sivalensis*. The premaxillæ in that specimen are intermediate in length between those of the domestic horse and the kiang, but approach nearer to those of the latter, the interval separating the molar series from the incisors being very much less than in *Equus caballus*.

A specimen of the extremity of the premaxillæ of a Siwalik horse, of the species of which I am uncertain, in the Indian Museum[1] shows that the incisors are placed very obliquely. The specimen represented in figure 5 of plate LXXXII of the "Fauna Antiqua Sivalensis" exhibits the same character. This oblique position of the incisors is a character distinguishing *Equus caballus* from *E. onager* and *E. hemionus*. Unfortunately I am unable to say whether any of these specimens of the premaxillæ belong to *E. sivalensis* or to the next species.

The cranium of *E. sivalensis* figured in the "Fauna Antiqua Sivalensis" is of great breadth across the orbits, a character which it possesses in common with the

[1] No. C. 186. This specimen is described by Falconer on page 187 of vol. I of the "Palæontological Memoirs," No. 305, as the mandible.

skull of *E. hemionus*. The relative proportions of the skulls of the above mentioned species may be estimated by taking the length of the molar series (inclusive of the persistent milk-molar) as unity, and seeing how many times this unit is contained in the interval separating the last true molar and the foramen magnum. This gives the following results :—

E. onager	= 1·07		1·07
„ hemionus	= 1·15		1·15
„ sivalensis	= 1·13	average	1·145
„ „	= 1·16		
„ caballus	= 1·26	„	1·305
„ „	= 1·35		

A distinct trace of a 'larmial' cavity is observable in the skull of *E. sivalensis*, as was first pointed out by Professor Huxley in the passage already cited. No living horse shows any trace of such cavity, though it is well developed in the hippotheres.

The Siwalik skulls are not sufficiently perfect to admit of any closer comparison with those of living species ; the points already observed, however, with the exception of the doubtful premaxillæ, certainly indicate a considerable resemblance between the crania of *E. sivalensis* and *E. hemionus*, coupled with the retention by the former of certain ancestral characters, which have been lost in the latter.

Mandible.—Two views of the greater portion of the horizontal ramus of the right side of the mandible of a Siwalik horse are given in the "Fauna Antiqua Sivalensis" (plates LXXXI, fig. 4 ; LXXXII, fig. 2)[1] under the name of *Equus sivalensis*. As similar jaws are not uncommon in the topmost Siwaliks, where *E. sivalensis* seems to be the commoner species, it is very probable that this reference is correct, though it cannot be considered as absolutely certain.

A very similar specimen, comprising the two rami, is in the collection of the Indian Museum (No. C.184), and was formerly in the collection of the Asiatic Society of Bengal ; its description by Dr. Falconer is given in the "Palæontological Memoirs."[2] The two foregoing specimens show that the lower jaw of *E. sivalensis* is of great vertical depth, and that the 'diastema' is shorter than in the common horse, and thereby comes nearer the length of that of the kiang. The following table exhibits the chief dimensions of the two Siwalik jaws (*a*, British Museum, *b*, Indian Museum specimen) and the corresponding dimensions of the jaws of *E. caballus* and *E. hemionus* :—

	E. cab.	E. siv. a.	E. siv. b.	E. hem.
Length of molar series	6·9	7·65	7·1	6·3
Depth „ jaw behind last molars	4·35	4·9	5·1	3·7
„ „ behind last premolar	3·1	3·85	3·84	3·2
„ „ at commencement of diastema	2·2	2·85	2·8	2·15
Length „ diastema	3·6	...	2·6	2·4

[1] In the description of the plates it is not mentioned that both figures are taken from the same specimen; the second figure is reversed.

[2] Vol. I, p. 188

These dimensions show that the relative proportions of the fossil jaw are nearer to those of the jaw of the kiang than to that of the horse. Unfortunately none of the specimens show the 'angle' of the mandible, in which there is such a marked difference in the two living species. The inferior border is arched, and very thick as in the kiang.

A symphysis of the mandible of a fossil horse in the Indian Museum, one of Mr. Theobald's Siwalik collection, shows that this portion of the jaw was elongated as in the living horse, and strikingly different from the corresponding part in the kiang. I cannot, however, say whether this specimen may not belong to *E. namadicus*; it agrees exactly in form with the symphysis of the mandible of *E. sivalensis* from the Siwaliks drawn in figure 6 of Plate LXXXII of the "Fauna Antiqua Sivalensis," but that reference may be incorrect.[1]

Upper milk-molars.—In figure 1 of plate XV are represented the milk-molars of a young colt of a species of *Equus* from the Siwaliks. It is probable, from the evidence of a specimen of upper milk-molars from the Narbada to be described under the head of the next species, that the present specimen belongs to *E. sivalensis*. These teeth agree in general form with the milk-molars of the domestic horse, presenting the elongated form usually characteristic of the deciduous series. These teeth are contained in a fragment of the right maxilla, collected by Mr. Theobald; the portion containing the first milk-molar has been broken away.

Other remains.—The Indian Museum possesses a considerable series of limb-bones of true horses from the Siwaliks. It is not, however, possible to be certain as to the species to which these should be referred, and accordingly only such of them will be noticed as bear on the question of the reputed monodactyle character of *Hippotherium antilopinum*.

Cannon and phalangeal bones.—There are a considerable series of 'cannon' and phalangeal bones in the Indian Museum, obtained by Mr. Theobald from the upper Siwaliks of the Kangra district, in company with the teeth of *Equus sivalensis*, which may probably be referred to that species, and certainly to the genus *Equus*, as the remains of *Hippotherium* have not been obtained from these higher beds. These bones are of a slender type, and many of them agree with the 'cannon' and phalangeal bones figured in the "Fauna Antiqua Sivalensis" as belonging to *H. antilopinum*.[2]

It may be noticed in passing that the last mentioned specimens are, as already said, those on the evidence of which M. Gaudry stated that *H. antilopinum* was unprovided with lateral phalanges. There is little, if any, doubt but that these bones belong to *Equus*. No hippothere has the first phalangeal bone so constricted.

Other corresponding bones are figured in the same plate of the "Faun.

[1] In the description of the plate the specimen is erroneously said to belong to the maxilla.

[2] Pl. LXXXV, figs. 11 to 14.

Antiqua Sivalensis" under the name of *Equus sivalensis*,[1] but of somewhat larger size. It is not impossible that these two types of bones may belong to the two species of Siwalik horses, or it is possible they may be merely sexual differences, as we have noticed considerable variations in the size of the teeth referred to *E. sivalensis*.

The proximal phalangeal bones are much compressed in the middle, and are of an elongated type, in both of which respects they resemble the phalangeals of *Equus hemionus*, and the zebras, and differ from the corresponding bones in the true horses.[2] All the evidence seems, therefore, to connect *E. sivalensis* with the asses and zebras, rather than with the domestic horse.

General character of species.—Judging by the remains above enumerated, which can certainly be referred to the present species, it would seem that *E. sivalensis* was most nearly allied to the Tibetan kiang, but that in its retention of a 'larmial' cavity and of the relatively large persistent first upper milk-molar, and in the small size of the grinding surfaces of the anterior 'pillars,' it retained characters connecting it with the ancestral genus *Hippotherium*. If certain remains belong to this species, in the inclination of its upper incisors and the form of the symphysis of the mandible it more nearly approached the horse; this is, however, doubtful. On the whole, I think it not improbable that this species may have been the ancestor of the living kiang of Tibet.

Distribution.—Remains of *E. sivalensis* have been hitherto obtained only from the higher beds of the sub-Himalayan Siwaliks to the eastward of the river Jhelum.

Species, 2 Equus namadicus, Falc. and Caut..

Synonym E. palæonus, F. and C.

History.—In plates LXXXI and LXXXII of the "Fauna Antiqua Sivalensis" are represented certain specimens of the cranium, teeth, and jaws of fossil horses under the names of *E. namadicus* and *E. palæonus* from the pleistocene deposits of the Narbada valley. It has already been stated that these remains in all probability belong to the same species, and they will be so considered here. There are no means of knowing on what grounds the authors of the above-quoted work distinguished the Narbada from the Siwalik horse, and it is possible that the distinction was made merely on the grounds of the different formations whence the specimens were obtained. In the following descriptions certain molar teeth from the Siwaliks will be noticed differing from those we have referred to *E. sivalensis*, and, as far as can be determined with the materials at command, apparently agreeing with the molars of the fossil horse from the Narbada beds. There is, however, as already said, always very considerable difficulty in determining the species

[1] Figs. 7, 8. [2] See. De Blainville's "Ostéographie" 'Equus,' pl. V.

of horses by means of the molar series alone, and there is consequently a certain possible element of doubt in the following determinations.

Upper molars.—In figure 3 of plate XV of this memoir are represented the earlier molar teeth of a true horse from the Narbada bone-beds, collected several years ago by Mr. Hacket of the Geological Survey. These teeth are implanted in a fragment of the left maxilla. At the anterior end of the series is seen the broken base of the first premolar, or persistent milk-molar (pm. 1), followed by the remaining three premolars (pm. 2 to pm. 4), while the last complete tooth is the first true molar (m. 1). The anterior teeth are determined to be premolars from the fact of the last of them (pm. 4), being less worn than the succeeding tooth (m. 1).

A comparison of these teeth with the upper molars of *E. namadicus* represented in plate LXXXII, figure 7 of the "Fauna Antiqua Sivalensis," will leave little doubt but that the two belong to the same species. They differ from the corresponding teeth of *E. sivalensis* by the larger size of the anterior 'pillar' in the last premolar.

Siwalik specimens.—In figure 3 of plate XIV of this memoir there is represented the left maxilla of a horse, collected by Mr. Theobald in the topmost Siwaliks of the Hushiárpúr district of the Punjab, exhibiting all the teeth of the molar series with the exception of the first premolar, or milk-molar (pm. 1), of which only the broken base remains. These teeth belong to the permanent series, and are in an intermediate condition of wear: an inspection of the figure will at once show that they differ very markedly from the molars of *E. sivalensis* represented in figure 2 of the same plate. This difference mainly consists in the greater length of the grinding surfaces of the anterior 'pillars' of the last two premolars (pm. 3, pm. 4), which exceeds the length of any of the corresponding surfaces in the true molars. All the anterior 'pillars' are, indeed, very much larger than those of the molar series of *E. sivalensis*.

The great difference in the form of the anterior 'pillars' of these teeth from those of the molars of *E. sivalensis* figured in the same plate, appears to leave little doubt but that they belong to another species. Comparing them with the teeth of *E. namadicus* from the Narbada, noticed above, the two series are seen to agree very closely in the great relative size of the anterior 'pillar' of the last premolar, though in the Siwalik specimen the same 'pillar' in the penultimate premolar (pm. 3) is equally well developed. Both specimens, however, agree in the relatively large size of the grinding surfaces of the anterior 'pillars,' especially in the premolars, and I think it not impossible that the two may belong to the same species. This inference is confirmed by a specimen of the right maxilla of a horse represented in figure 4 of plate XV, and collected by Mr. Theobald in the Siwaliks of the Punjab, which seems to be intermediate between the two specimens above described.

The specimen of a right maxilla of a horse from the Siwaliks, represented in

plate LXXXII, figure 1 of the "Fauna Antiqua Sivalensis," under the name of *E. sivalensis*, appears to agree with the last mentioned specimen.

Finally, taking the Narbada specimen as the type of the teeth of *E. namadicus*, it seems highly probable that the specimen represented in plate XV, figure 4, belongs to the same species, and this being so, it is difficult to separate the specimen represented in plate XIV, figure 3, which certainly does not belong to *E. sivalensis*, and if not referred to *E. namadicus* must belong to a new species.

Upper milk-molars.—If the permanent molars described above have left any doubt as to there being two species of fossil Indian true horses, this doubt is at once dispelled if the upper milk-molars of a horse from the Narbada represented in figure 2 of plate XV are compared with the corresponding teeth from the Siwaliks represented in figure 1 of the same plate. These teeth are implanted in a fragment of a right maxilla, collected by Mr. Hacket in the pleistocene deposits of the Narbada valley. At the right side of the figure is seen the small first milk-molar (mm. 1), immediately behind which a fragment of the second milk-molar (mm. 2), and the germ of the displacing second premolar can be seen; the two next teeth (mm. 3, mm. 4) are the third and fourth milk-molars, as is proved by their state of wear, and by the germs of replacing premolars below them; while the last tooth (m. 1) is the first true molar.

By comparing these teeth with the upper milk-molars represented in figure 1 of the same plate, and referred to *E. sivalensis*, the essential difference between the two will be at once apparent. The present milk-molars differ indeed from those of any species of true horse with which I am acquainted by the nearly square form of their grinding surfaces, and thereby approach the milk-molars of some of the hippotheres, like *H. antilopinum*.

As no other species of horse, besides *E. namadicus*, is known from the Narbada these teeth are provisionally referred to that species: taken with the Siwalik milk-molars they unquestionably prove the existence of two species of fossil Indian horses.

Comparisons.—Assuming that all the specimens described above belong to *E. namadicus*, we may predicate of that species that the upper molars are distinguished by the relatively great length of the grinding surfaces of the anterior 'pillars,' a character especially well-marked in the premolars, but that there is a certain amount of variability in this character. The species is further distinguished from all living horses by the square form of the crowns of the upper milk-molars; and is also marked by the very general retention of the first milk-molar in the permanent series, though, judging from the specimens figured in the "Fauna Antiqua Sivalensis," this character is not always noticeable; when present the persistent first milk-molar is always of much larger size than in existing horses.

In *Equus caballus* the grinding surfaces of the anterior 'pillars' of the upper true molars are about equal in size to those of *E. namadicus*. In the premolars they are, however, smaller. The enamel islands in the existing horse

generally exhibit less plication of their borders, and the first milk-molar, if present, is always smaller than in *E. namadicus*.

In *E. hemionus* the grinding surfaces of the anterior 'pillars' of the upper molars are of comparatively small size, and the first milk-molar is always shed at an early period.

In *E. onager* the anterior 'pillars' of the upper molar series present a close resemblance to those of *E. namadicus*, their grinding surfaces being long, and that surface in the last premolar being longer than in any other tooth. In the recent species, however, the central-enamel islands have their borders less plicated than in the fossil, and the small first milk-molar disappears at an early age.

I am unable to make any comparisons between the teeth of *E. namadicus* and those of the living African *Equidæ*, and I cannot identify them with any of the fossil European or American forms.

Skull.—From a cast of the incomplete skull figured in plate LXXXI, figures 5 and 6, of the "Fauna Antiqua Sivalensis," the only comparison that I can make is that the skull belongs to the elongated type of that of the common horse, the relative length of the molar series to that of the interval between the last true molar and the foramen magnum being 1 to 1·28. This shows that in respect to the skull, *E. namadicus* is more nearly related to the horse than to the wild asses of Asia (see above, p. 24).

Mandible.—In the "Fauna Antiqua Sivalensis" (plate LXXXI, fig. 7) a lower jaw of a fossil horse from the Narbada, referred to *E. namadicus*, seems to be indistinguishable from that referred to *E. sivalensis*. This opens up the question whether the jaw referred to the latter is correctly determined, and whether it may not really belong to *E. namadicus*; on the other hand, it is quite likely that *E. sivalensis* may occur in the Narbada. As there seems at present no means of settling this question, I have adopted provisionally Falconer's determination of the mandible of *E. sivalensis*, and shall merely refer here to another form of mandible from the Siwaliks, which may belong to *E. namadicus*. The teeth of the specimen in question are represented in figure 5 of plate XII of this volume; they comprise the three true molars. The specimen consists of a portion of the right ramus of the mandible, and was obtained by the late Conductor J. Dawe, from the Siwaliks in the neighbourhood of Náhan; it was referred by Dr. Falconer to *E. sivalensis*. The elongated teeth and the bold loops of the enamel render it probable that the specimen belongs to *Equus*. The jaw is more slender than the specimen figured in the "Fauna Antiqua Sivalensis" as the mandible of *Equus sivalensis*, and yet the teeth are of absolutely larger size, indicating the probability of the specific distinctness of the two specimens. It would be unsafe to make any more precise attempt at the specific identification of the present specimen.

Other remains.—In figures 9, 10, 11 of plate LXXXII of the "Fauna Anti-

[1] See "Pal. Mem." Vol. I, p. 187 (No. 307).

qua Sivalensis," there are represented the anterior extremities of the skull and mandible, and the lower milk-molar dentition of a fossil horse from the Narbada, under the name of *Equus palæonus*. As the corresponding parts of the skeleton of *E. namadicus* are not represented in the "Fauna Antiqua Sivalensis," it is now impossible to understand what could have induced the authors of that work to separate these remains from *E. namadicus*. Until, therefore, any evidence which should lead to the adoption of a contrary view be produced, these remains are, following the suggestion of the late M. Lartet, referred to that species. The name of *E. palæonus* must consequently be abolished. The remains above noticed do not present any characters requiring special notice.

Distribution.—Remains of *E. namadicus* have been obtained from the pleistocene beds of the Narbada, and if the above determinations be correct, from the topmost Siwaliks, in company with *Bubalus palæindicus* and *Camelus sivalensis*, in beds which are probably high up in the pliocene series, if, indeed, they also do not belong to the pleistocene. Remains of a fossil horse have been obtained from the older alluvium of the Jamna valley, very possibly belonging to the present species, though this cannot be certainly determined.

If it should turn out that the identification of the second species of Siwalik horse with *E. namadicus* be incorrect, the former remains will have to be referred to a new species.

List of the more important recent works and memoirs on the osteology and palæontology of Equus *and* Hippotherium, *consulted in this memoir.*

Baker, W. E.

"Selected specimens of the Sub-Himalayan Fossils in the Dádupur Collection." 'Fossil Horses.' 'Jour. As. Soc., Bengal,' Vol. IV, p. 566.

Burmeister, H.

"Los caballos fosiles de la Pampa argentina." Buenos Ayres, 1875. (*Equus neogæus E. principalis, E. argentinus*, and *E. curvidens*).

Falconer, H.

'Letter from—regarding Siwalik fossils.' 'Jour. As. Soc., Bengal,' Vol. IV, p. 58 (Hippotherium).

" and Cautley.

"Fauna Antiqua Sivalensis." London, about 1846.

" and Walker."

"Catalogue of Fossil Vertebrata in Museum, As. Soc., Bengal." Calcutta, 1859.

Forsyth—Major, J. C.

"Beiträge zur Geschicte der fossilen Pferde, inbesondere italiens." "Abhand. d. Schweiz. pal. Gesel." Vols. IV. and VII.

Georgi.

'Etudes zoölogiques sur les Hémiones et quelques autres espèces chevalines." 'Ann. Sci. Nat.' Zoölogie. Ser 5. Vol XII., p. 5, 1869.

GERVAIS, P.

"Zoölogie et Paléontologie Françaises." Paris, 1859, cap. vi.

GAUDRY, A.

"Animaux Fossiles et Géologie de l'Attique." Paris, 1862—67 (*Hippotherium gracile*).

"Animaux Fossiles du Mont Léberon." Paris, 1873. (*Hippotherium gracile*; milkdentition).

"Les Enchainements du Monde Animal, etc." Paris, 1878, cap. v.

GRAY, J. E.

"Catalogue of Carnivorous, Pachydermatous, and Edentate Mammalia in the British Museum." London, 1869.

"Hand-List of the Thick-skinned and Ruminant Mammalia in the British Museum." London, 1873.

"Notes on the skulls of *Equus hemionus* and *Equus kiang*." 'P. Z. S.' 1849.

"Revision of Family Equidæ." 'Zool. Journal,' Vol. I, p. 241, 1825.

HENSEL.

"Uber Hipparion mediterraneum." 'Abhand. d. k. Akad. d. Wissen. z. Berlin.' 1861, p. 27.

HUXLEY, T. H.

"Anatomy of Vertebrated Animals." London, 1871.

KAUP, J.

"Beitrage zur naheren Kentniss der urweltlichen Saugethiere." Darmstadt and Leipsic, part 5. [*Hippotherium gracile* and *H. mediterraneum*.]

KOWALEVSKY, W.

"Sur l'*Anchitherium aurelianense* (Cuv.) et sur l'Histoire Palaéontologique des Chevaux." 'Mem. d. l. Akad Imp. d Sci. d. S. Pet.' Ser. 7, Vol. XX, No. 5.

LEIDY, J.

"Contributions to the Extinct Vertebrate Fauna of the Western Territories." Philadelphia, 1873. [*Equus occidentalis* and *E. major*.]

LYDEKKER, R.

"Notices of New and other Vertebrata from Indian Tertiary and Secondary Rocks." 'R. G. S. I.' Vol. X, p. 31 [*Sivalhippus theobaldi*].

"New or Rare Mammals from the Siwaliks." *Ibid.* p. 82 [*Sivalhippus* shown to be *Hippotherium*].

"Note on some Siwalik & Jamna Mammals." *Ibid.* Vol. XV, (in the press) [*Equus* from Jamna alluvium.]

"Observations on the Ossiferous Beds of Hundes in Thibet," Ibid Vol. XIV, p. 178. (Occurrence of remains of horses in these deposits).

MEYER, H.

"Uber die fossilen Reste von Wirbelthieren, welche die Herren von Schlagintweit von ihren Reisen in Indien und Hoch-Asien mitgebracht haben." 'Paläontographica,' Vol. XV, p. 1. (Shows that Siwalik hippothere = European *H. gracile*).

MURCHISON, C.

"The Palæontological Memoirs of the late Hugh Falconer," Vol. I, p. 186. London. 1868.

OWEN, R.

"Description of the Cavern of Bruniquel and its Organic Contents," part 2. 'Phil. Trans.' 1871, p. 535.

"Fossil Mammalia," 'Zoology of the Voyage of the *Beagle*.' London 1840.

"History of British Fossil Mammals and Birds." London, 1846.

"Odontography," London, 1840-45.

"On Fossil Remains of Equines from Central and South America referrable to *Equus conversidens* Owen, *Equus tau*, Owen, and *Equus arcidens*, Owen." 'Phil. Trans.' 1871, p. 559.

POLIAKOF, M.

"Supposed New Species of Horse from Central Asia." 'Ann. Mag. Nat. Hist.' Ser. 5 Vol. VIII, No. 43, p. 16. [*Equus prezewalkski*].

POMEL, A.

"On the Occurrence of a Species of *Hippotherium* in Algeria." 'Bul. Soc. Geol.' Vol. VI, p. 213.

RYDER, J. A.

"Evolution and Homologies of the Incisors of the Horse." 'Proc. Acad. Phil.' 1877, p. 152.

RUTIMEYER, L.

"Beitrage zur Kenntniss der fossilen Pferde, &c.," 'Verhand, d. natfor, Gesel in Basle,' Vol. III, No. 4.

"Weitere Beitrage zur Beurtheilung der Pferde der Quaternar—Epoche." 'Abhand, d Schweiz. pal. Gesel.' 1875.

NOTE.

For the American species the numerous memoirs of Messrs. E. D. Cope, J. Leidy, and O. C. Marsh, in the publications of the American Surveys, and in the "American Journal of Science and Art," have been consulted, but are not quoted at length, as the species described do not approach the Indian forms. A recent memoir by Veterinary Surgeon Thomas, of the French Cavalry, entitled "Recherches sur Equidés fossiles des environs de Constantine,"[1] is not procurable in India, and may contain species not mentioned in my list. The second part of Professor Forsyth Major's memoir only reached India while the above was passing through the press, and the new species therein mentioned is therefore, only incidentally referred to.

[1] 'Bul. Soc. d. Sci. phys. et Nat. d' Alger,' 1879.

PLATE XI.

Fig. 1. HIPPOTHERIUM ANTILOPINUM. Falc. and Caut.; part of left maxilla, showing premolars 3 and 4 (pm. 3, pm. 4), and true molars 1 and 2 (m. 1 and m. 2), from a specimen collected by Mr. Theobald in the Siwaliks of Niki, in the Punjab (No. C. 139, Ind. Mus.). The teeth are in an early stage of wear, but later than in figure 3.

Fig. 2. HIPPOTHERIUM ANTILOPINUM. Falc. and Caut; the milk-molar dentition of the left side, of a colt about one year old; from a palate specimen collected by Mr. Theobald in the Siwaliks of Niki. The specimen shows the four milk-molars (mm. 1 to mm. 4), and the unworn germ of the first true molar (m. 1), (No. C. 158, Ind. Mus.). The teeth are in an early stage of wear.

Fig. 3. HIPPOTHERIUM THEOBALDI. Lydekker. Fragment of the left side of the maxilla showing the two last premolars (pm. 3, pm. 4), and the two first true molars. Collected by Mr. Theobald in the Siwaliks of Niki (No. C. 151, Ind. Mus). The teeth are in a very early stage of wear.

Fig. 4. HIPPOTHERIUM THEOBALDI. Lydekker. Fragment of the left maxilla of a colt, about one year old, showing the three last milk-molars (mm. 2, mm. 3, mm. 4), and the broken base of the first tooth of the same series (mm. 1). Collected by Mr. Theobald in the Siwaliks of Kaipar, in the Punjab (No. C. 153, Ind. Mus.). The teeth have only just come into wear.

All the specimens are represented of the natural size.

PLATE XII.

Fig. 1. HIPPOTHERIUM ANTILOPINUM (?) Falc. and Caut. Fragment of the left ramus of the mandible of a colt, showing the three last milk-molars (mm. 2, mm. 3, mm. 4), the first true molar (m. 1), and the alveolus of the second (m. 2). Collected by Mr. Theobald in the Siwaliks of the Punjab (No. C. 148, Ind. Mus.).

Fig. 2. HIPPOTHERIUM THEOBALDI. Lydekker. The greater part of the left ramus of the mandible, wanting a small portion in the middle, and showing the second and third premolars (pm. 2, pm. 3), and the three true molars (m. 1, m. 2, m. 3). Collected by Mr. Theobald in the Siwaliks of Niki, in the Punjab, associated with the specimen drawn in figure 3 of plate xi. (No. C. 159, Ind. Mus.).

Fig. 3. HIPPOTHERIUM ANTILOPINUM (?) Falc. and Caut. Part of left ramus of the mandible, containing the third and fourth premolars (pm. 3, pm. 4), and the three true molars (m. 1, m. 2, m. 3). Collected by Mr. Theobald in the Siwaliks of the Punjab. (No. C. 142, Ind. Mus).

Fig. 4. HIPPOTHERIUM THEOBALDI. Lydekker. Part of the right ramus of the mandible, showing the two last premolars (pm. 3, pm. 4), and the three true molars (m 1, m 2, m 3). Collected by Mr. Theobald in the Siwaliks of Jabi, in the Punjab. (No. C. 172, Ind. Mus). These teeth are characterised by an unusual quantity of cement.

Fig. 5. EQUUS, sp. Part of the right ramus of the mandible, showing the three true molars. From the collection of the Asiatic Society of Bengal; obtained by the late Conductor J. Dawe near Náhan. (No. C. 173, Ind. Mus.).

All the specimens are represented of the natural size, and are viewed from the outer side.

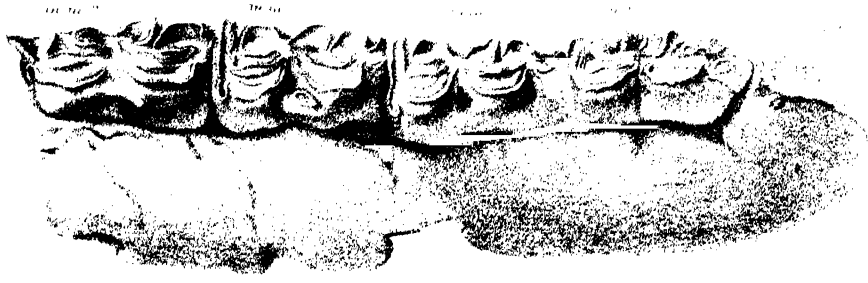

PLATE XIII.

Hippotherium theobaldi Lyd.

Fig. 1. Third, or fourth left upper premolar, collected by Mr. Theobald in the Siwaliks of the Punjab. (No. C. 157, Ind. Mus.).

Fig. 2. Second right upper premolar, collected by Mr. Theobald in the Siwaliks of the Punjab. (No. C. 155, Ind. Mus.).

Fig. 3. Bones of the anterior foot: the terminal phalange of the middle digit is broken: the three lateral phalanges on the left side of the specimen (right side of figure), and the right lateral metacarpal, have been restored from the corresponding bones of the opposite side. The specimen was collected by Mr. Theobald in the Siwaliks of Niki, in the Punjab, and not improbably belonged to the same individual as the upper jaw represented in figure 3 of plate XI.

All the specimens are represented of the natural size.

PLATE XIV.

Fig. 1. EQUUS SIVALENSIS. Falc. and Caut. Part of the right maxilla, exhibiting the third and fourth premolars, and the three true molars: from a specimen collected by Mr. Theobald in the higher Siwaliks of the village of Rúpúr, in the Punjab. (No. C. 181, Ind. Mus.).

Fig. 2. EQUUS SIVALENSIS. Falc. and Caut. The complete permanent molar dentition of the left side, from a skull collected by Mr. Theobald in the higher Siwaliks, near the village of Pádri, in the Punjab. The teeth are in an intermediate condition of wear. (No. C. 179, Ind. Mus.)

Fig. 3. EQUUS NAMADICUS. Falc. and Caut. Part of the left maxilla, showing the base of the first premolar (pm. 1), and the whole of the remaining molar teeth of the permanent series. From a specimen collected by Mr. Theobald in the topmost Siwaliks of the Hushiárpúr district. Since the specimen was figured, the second premolar (pm. 2) has unfortunately crumbled to pieces. (No. C. 194, Ind. Mus.)

All the specimens are represented of the natural size.

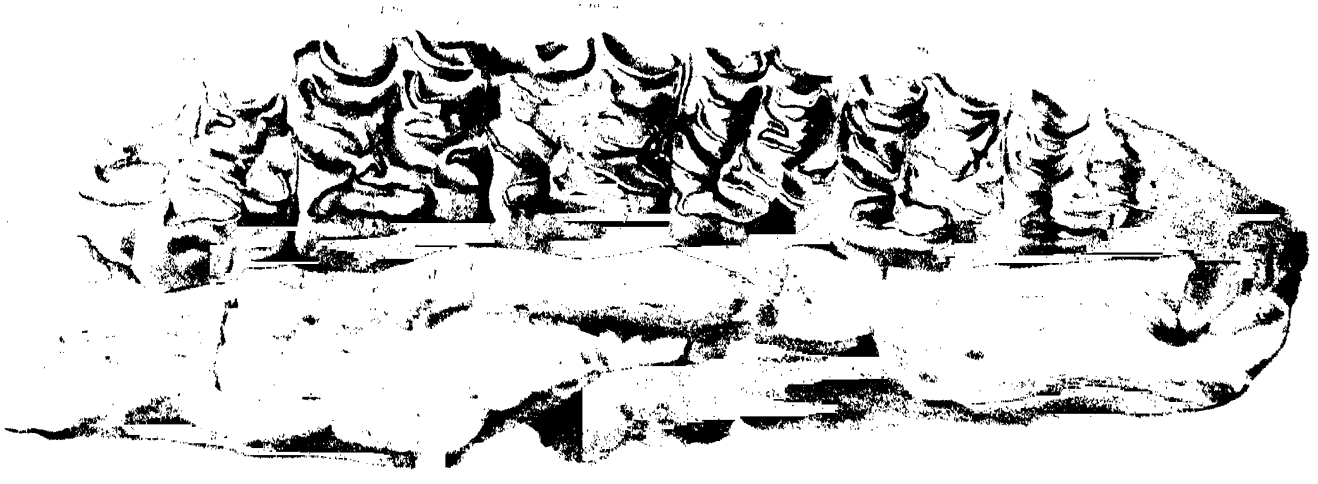

PLATE XV.

Fig. 1. EQUUS SIVALENSIS. Falc. and Caut. Fragment of the right maxilla of a colt, about one year old, showing the three last milk-molars (mm. 2 to mm. 4), and the germ of the first true molar. From a specimen collected by Mr. Theobald in the topmost Siwaliks of the Hushiárpúr district. (No. C. 182, Ind. Mus.).

Fig. 2. EQUUS NAMADICUS. Falc. and Caut. Fragment of the right maxilla of a colt, about two years old, showing the first milk-molar (m. 1), parts of the second milk-molar and second premolar (mm. 2, pm. 2), the third and fourth milk-molars (mm. 3, mm. 4), and the first true molar (m. 1). From a specimen collected in the Narbada valley by Mr. Hacket. (No. F. 3, Ind. Mus.).

Fig. 3. EQUUS NAMADICUS. Falc. and Caut. Fragment of the left maxilla, showing the base of the first premolar (pm. 1), the three latter premolars (pm. 2-4), and the first true molar (m. 1). The teeth are in an early state of wear. From a specimen collected by Mr. Hacket in the Narbada valley. (No. F. 2, Ind. Mus.)

Fig. 4. EQUUS NAMADICUS. Falc. and Caut. Fragment of the right maxilla, showing three premolars (pm 2. to 4), and the first true molar (m. 1); the teeth are well worn. Collected by Mr. Theobald in the higher Siwaliks of the Kangra district. (No. C. 195, Ind. Mus.).

All the specimens are represented of the natural size.